Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 277 694 A2

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 88200167.0

(51) Int. Cl.4: G01N 33/36

(22) Date of filing: 02.02.88

(30) Priority: 05.02.87 BE 8700088

(43) Date of publication of application: 10.08.88 Bulletin 88/32

(84) Designated Contracting States: BE CH DE ES FR GB IT LI

(71) Applicant: Wetenschappelijk en Technisch Centrum van de Belgische Textielnijverheid, afgekort tot Centexbel
Montoyerstraat 24
B-1040 Brussels(BE)

(72) Inventor: Bossuyt, Filip Oktaaf Pieter
Burgemeester Coussensstraat 9
B-8000 Kortrijk(BE)

(74) Representative: Debrabandere, René et al
Vereenigde Octrooibureaux Belgie N.V.
Charlottalei 48
B-2018 Antwerpen(BE)

(54) **A method of measuring the yarn density of a woven fabric or the stitch density of a knit fabric for readjusting the production machine in question.**

(57) A method of measuring the yarn density of a woven fabric or the stitch density of a knitted fabric by recording a video image of the woven or knitted fabric to be examined by means of a video camera, converting the video image by an analog-to-digital converter into digital video information, storing the digital video information in a digital image memory and converting said information by a central processing unit into the yarn density or stitch density. The digital video information is converted by a digital band filter (14) with central circle frequency (ω_0) into a yarn or stitch density, and that the digital band filter (14) is arranged in such a manner that it operates according to the formula:

$$Y_k = A_n.X_{k-n} + A_{n-1}.X_{k-n+1}.... + A_0X_k - B_1.Y_{k-1} - B_2Y_{k-2}... - B_{-n}Y_k$$

wherein:
Y_k represents a series of points of the digital information characteristic at interspace T before the digital filtering; Y_k represents the said series of points k of the filtered digital information characteristic via digital filtering at the same interspace T; the coefficients A and B are a function of the quality Q, the central circle frequency ω_0 and the interspace T.

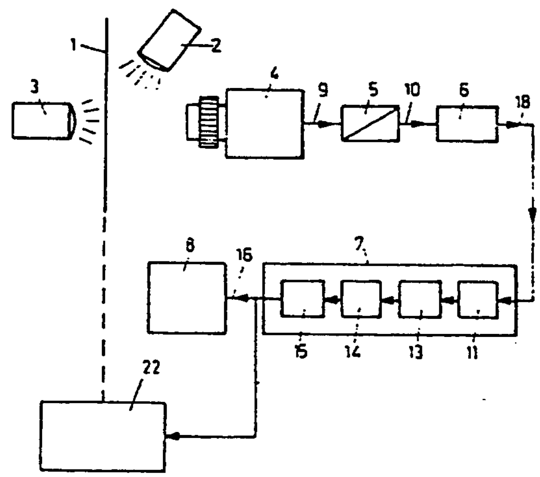


FIG.1

EP 0 277 694 A2

A method of measuring the yarn density of a woven fabric or the stitch density of a knit fabric for readjusting the production machine in question.

This invention relates to a method of measuring the yarn density of a woven fabric or the stitch density of a knit fabric, for readjusting the production machine in question, such as a loom, knitting machine or tenter frame, automatically and continuously, in case of deviation from the desired density.

In the weaving industry, it is useful to know online the weft density of the fabrics produced: on the basis of this data, the operator can adjust the instructed weft density on the production machine as accurately as possible. Approximating this weft density has an economic importance: too high a weft density naturally results in loss of raw materials, and too low a density leads to complaints from customers. Moreover, a measurement of the weft density also permits to detect certain errors, such as beating errors.

In the knit fabric industry, the dimensional stability of the knit fabric is one of the major quality characteristics of the finished product. By measuring the stitch density during several phases of the production process, it is possible better to control the stability of the knit fabrics produced.

The measuring method commonly used is the manual count of the number of yarns over a given distance (minimum distances are specified according to the standards for different density categories). This method has the advantage that it is simple, but on the other hand it is not so accurate and time-consuming.

An alternative for the above method is to ravel out a piece of cloth with known dimensions, followed by a count of the yarns raveled out, which is highly time-consuming.

A third known method is the use of fine grids laid over the piece of textile to be analyzed. With a well-chosen grid, there is obtained a certain moiré pattern, from which the density can easily be determined. This method has the advantage of being quicker and less stressful; accuracy, however, is less good.

A further drawback of this known method is that the operator, after establishing a deviation in density, always has to adjust the loom, knitting machine or tenter frame, which is a relatively slow process, so that the deviation in density is not removed as quickly as necessary. Moreover, such a process is time-consuming and insufficiently accurate.

It is an object of the present invention to remove these drawbacks and to provide a method of measuring the yarn density of a fabric or the stitch density of a knit fabric that is highly accurate and fast, and in which the measuring data corresponding with the yarn density and stitch density, is used for controlling the loom, knitting machine or tenter frame concerned.

To that end, a video image of the woven or knitted fabric is picked up by a video camera and the video image is converted in an analog-to-digital converter into digital video data, which is stored in a digital image memory for it to be digitally converted by a central processing unit into the yarn density or stitch density by means of a digital filter with a central circle frequency, said filter being arranged so that it is operated according to the formula:

$$Y_k = A_n.X_{k-n} + A_{n-1}.X_{k-n+1}.... + A_0 X_k - B_1. Y_{k-1} - B_2 Y_{k-2}... - B_n Y_k$$

wherein:

X_k represents a series of points of the digital data characteristic at interspace T before the digital filtering; Y_k represents the said series of points k of the filtered digital data characteristic after digital filtering at the same interspace T; the coefficients A, and B are a function of the quality Q, the central circle frequency ω_0 and the interspace T.

The filtered digital data characteristic or the yarn or stitch density data obtained after digital filtering is supplied to the loom, knitting machine or tenter frame for controlling the loom, knitting machine or tenter frame in such a manner that it delivers a woven or knitted fabric whose density can be accurately maintained within certain limits. Possibly, this density data can also be supplied to a read-out unit for visualizing these data, on the basis of which the operator can see to what extent there are deviations in the woven pattern.

Advantages of the method according to the present invention are that the measurement can be easily performed automatically with a high accuracy, that human errors during counting, e.g. of the number of stitches, are excluded, and that the measurement is done much more quickly than with the manual method.

Moreover, the method allows a continuous measurement, permitting a quicker intervention in the production process, so that a constant quality of the woven or knitted fabric is obtained.

In a particular embodiment of the method according to the present invention, the central circle frequency ω_0 of the digital filter is designed to be adjustable as a function of the yarn or stitch density of the fabric to be examined.

In an advantageous embodiment of the method according to the present invention this data is enhanced before the conversion of the digital video

data.

Preferably, enhancing the digital video data includes at least one of the following steps: contrast expansion, elimination of redundant data from the digital video data and accentuation of relevant data in the digital video data.

The yarn or stitch frequency graph can be calculated by isolating one line from the digital video data or by calculation from the digital image information of a row or column histogram.

The present invention also relates to an apparatus that is particularly suitable for performing the method according to the present invention.

The invention accordingly relates to an apparatus for measuring the yarn density of a woven fabric or of the stitch density of a knit fabric, which is characterized in that it comprises:

- a video camera arranged to record an analog video image from the woven or knitted fabric to be examined;
- an analog-to-digital converter converting the analog video image into digital video data;
- an image memory for storing the digital video data, and
- a processing unit for converting the digital video data into the yarn or stitch density by means of a digital filter having a central circle frequency.

Other features and advantages of the present invention will become apparent from the following description of a method of measuring the yarn density of a woven fabric or of the stitch density of a knit fabric according to the present invention; this description is given by way of example only and is not intended to limit the invention in any way; the reference numerals refer to the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of the apparatus for measuring the yarn or stitch density according to the present invention;

Fig. 2 is a diagram of the digital filter used in the apparatus;

Fig. 3 is a graph of the digitalized picture points or pixels of a line recording or of a histogram before digital filtering;

Fig. 4 is a graph of the digitalized picture points or pixels of the same line recording or histogram of Fig. 2 after digital filtering;

Fig. 5 is a graph of the picture points to be calculated before and after digital filtering;

Fig. 6 is a graph of the digitalized picture points of a line recording or of a histogram of the digital filtering serving as a basis for the calculation of the yarn or stitch density.

In the various figures, the same reference numerals relate to the same elements.

The woven or knitted fabric 1 to be examined, according to its properties and the circumstances, is exposed with incident light from a light source 2 or with light passing through it from a light source 3.

The measuring arrangement according to the present invention comprises a camera 4, which may be a CCD video camera, a fast analog-to-digital converter 5, an image memory 6, a processing unit 7, containing the means for digitally processing the image and after which the data is supplied to a display unit 8, and as control data to a production machine 22, such as a loom, knitting machine or tenter frame.

An analog video image of the woven or knitted fabric 1 is recorded by the camera 4 during the manufacture or treatment of said woven or knitted fabric by the production machine 22. The analog video image is applied through lead 9 to the fast analog-to-digital converter 5, which converts the analog video image into digital video data, consisting of a series of measuring points having a digital value. From the fast analog-to-digital converter 5 through lead 10 the digital video data is applied to, and stored in, the image memory 6. In this stage the digital video data is not yet suitable for further processing, since it still contains redundant data. This redundant data should first be removed from the digital video data, which takes place in the processing unit 7, containing an image enhacing unit 11 for enhancing the digital image or the digital video data.

To that end, the digital video data is retrieved from the image memory 6 via connection 18 and applied to the image enhancing unit 11 of the processing unit 7. Accordingly, this image enhancing unit 11 performs preparatory operations on the digital video data, such as image enhancement by e.g. contrast expansion, elimination of redundant data, accentuation of relevant data and the like.

After this step, a yarn or stitch frequency graph 12 is derived from the enhanced video data by a part 13 of the processing unit 7. This can be done in two ways:

A first way is the isolation of one line from the video image now existing in the form of digital video data.

By considering the brightness of each digital measuring point of a line in function of the place of that measuring point in the line, there are obtained a series of points defined as the data corresponding with the yarn or stitch frequency graph 12, which graph is shown in Fig. 3.

A second manner is the calculation of a row or column histogram. Per row or column, the intensities of all digital measuring points present in the row or column under consideration are summed. The graphic representation of all sums of intensities forms a row or column histogram that likewise has the form of the graph of Fig. 3.

The computation of the density from the data

corresponding with the yarn frequency graph of Fig. 3 takes place in two stages.

The first stage comprises a pre-treatment of the graph of Fig. 3 by digital filtering, in a digital filter unit 14 of the processing unit 7. In the ideal case of a perfectly regular fabric, whether woven or knitted, the data corresponding with the yarn frequency graph 12 is a perfectly periodic signal having a constant frequency.

In a normal case, however, this signal is not perfectly periodic: various spurious and interfering frequencies are superposed on the fundamental frequency. These spurious frequencies are filtered out in the digital filter unit 14 by means of a digital band filter, a digital low-pass filter and/or a digital high-pass filter present therein.

Band filters are especially interesting, because they enable the accentuation of a specific frequency band in the signal. The central frequency of that band filter is then adjusted each time by the operator of the loom, knitting machine or tenter frame in function of the fabric being examined.

Fig. 2 diagrammatically shows an embodiment of the digital filter 14 with central circle frequency ω_0 of Fig. 1. This filter comprises a plurality of delay units $23a_1 \ldots a_n$ and $23b_1 \ldots b_n$, and a summing circuit 24. The manner in which these delay units are connected to the summing circuit is further shown in Fig. 2, and they jointly form a specific digital filter algorithm.

The yarn or stitch frequency graph 12, see Fig. 3, supplied to the input of filter 14, consists of a row of points X_k being at an interspace T from each other, see Fig. 5. These will be converted by the digital filter algorithm to a new row of points Y_k at the output of filter 14.

The general form of such a filter algorithm is as follows:

$$Y_k + B_1.Y_{k-1} + B_2.Y_{k-2} \ldots + B_n.Y_{k-n} = A_m.X_{k-m} + A_{m-2}.X_{k-m+1} \ldots + A_0.X_k$$

or

$$Y_k = A_m.X_{k-m} + A_{m-1}.X_{k-m+1} \ldots + A_0.X_k - B_1.Y_{k-1} - B_2.Y_{k-2} \ldots - B_m.Y_{k-}$$

The filter coefficients $A_0 \ldots A_n$ and $B_0 \ldots B_n$ define the nature of the filer and should therefore be calculated from the filter specifications.

For a classical 2nd order band filter with central circle frequency ω_0 and quality factor Q, the following formula is found:

$$Y_k + B_1.Y_{k-1} + B_2.Y_{k-2} = A_0.X_k + A_1.X_{k-1} + A_2.X_{k-2}$$

or

$$Y_k = A_2.X_{k-2} + A_1.X_{k-1} + A_0.X_k - B_1.Y_{k-1} - B_2.Y_{k-2}$$

The coefficients A and B are a function of Q, ω_0 and T (the distance between two successive points of the row of points) in which:

$$AO = 2\alpha$$

$$A1 = -2\alpha.e^{-\alpha}\left(\frac{\sin\alpha\beta}{\beta} + \cos\alpha\text{-}\beta\right)$$

$$A2 = 0$$

$$B1 = -2e^{-\alpha}.\cos\alpha\beta$$

$$B2 = e^{-2\alpha}$$

wherein

$$\alpha = \frac{\omega_0 T}{2Q} \qquad \beta = \frac{2Q}{\sqrt{4Q^2-1}}$$

In the classical analog filters, filtering takes place by means of physical components (capacitor, coil). The value of these components and the manner in which they are connected determines the characteristics of the filter (cut-off frequency, band width, quality factor, high-pass or low-pass). When these characteristics are to be changed, it is necessary to intervene in the circuit arrangement. The electrical diagram or the value of one of the components thereof will have to be changed. It is not possible to render the central circle frequency ω_0 controllable without, in this case too, changing the filter value.

In a digital filter, however, filtering takes place by means of mathematical operations; in other words, by an algorithm applied to a row of numbers in the memory of a computer. The characteristics of a digital filter are determined by a number of coefficients and not by physical components. The filter characteristics can thus be adjusted in a simple and fast manner; the filter is entirely software-programmable.

For filtering the yarn frequency characteristic, it is necessary to have a band filter whose central frequency is equal to the yarn frequency of the textile to be measured. This can be realized easily with the digital filtering described herein.

It is even possible to adjust the filter on the basis of the measured density, in other words to render the system "self-teaching". In a teaching phase, filtering takes place then on the basis of an estimated central circle frequency. On the basis of the measurements, this central circle frequency is then adjusted to obtain an optimally effective filtering.

The second phase comprises the computation proper of the yarn density from the data filtered out from the digital filter unit 14, corresponding with the

yarn or stitch frequency graph 17, shown in Fig. 4, in a computing unit 15 of the processing unit 7.

First, the average of the filtered data corresponding with the yarn or stitch frequency graph 17 is computed and detracted from the data corresponding with the graph, after which the number of whole periods N in the data corresponding with graph 17 is counted. Subsequently, the number of picture points (or pixels) N_p in these N periods is counted. The yarn or stitch density is then obtained by the simple step:

yarn or stitch density = $N/(N_p \times s)$

in which s is a scale factor defined by the calibration procedure to be described hereinafter.

To obtain a density measurement that is as accurate as possible (absolute density measurement), use is made of a calibration pattern that may be a separate, specific pattern for each type of fabric.

A calibration pattern consists e.g. of a metal foil on which are provided a plurality of parallel lines that are regularly interspaced. This interspace is accurately determined.

Such a calibration pattern is read out by means of the measuring arrangement shown in Fig. 1 and the frequency characteristic of this read-out calibration pattern is calculated, after which the number of whole periods N_y and the number of pixels N_yP are counted from this frequency characteristic. The length of one pixel, i.e. the line distance s_y of the calibration pattern, can then be represented by

$s_y = N_y/N_y P$

This s_y corresponds with the above average scale factor s.

By replacing s in the above indicated expression of the yarn or stitch density by the expression indicated for s_y, there is obtained the absolute yarn or stitch density measurement.

In Fig. 6, 19 indicates one period of the data corresponding with the filtered yarn or stitch frequency graph, 20 the number of periods N proportional to N_p, the number of pixels, and 21 one line recording or histogram. The same method applies to the calibration pattern.

The result obtained is then applied via the connection 16 to the read-out unit 8 of a known type, on which the yarn or stitch density then appears in a form permitting the operator of the loom, knitting machine or tenter frame to read out and check the yarn or stitch density.

The result obtained is applied, likewise through the connection 16, to the loom, knitting machine or tenter frame 22 to adjust it for the instantaneous control of the yarn or stitch density, with the result that a product is supplied whose density can be accurately maintained within well defined limits.

In the above manner the yarn or stitch density can be obtained in a very fast and accurate manner with the apparatus described herein, which has a relatively simple construction, so that a continuous and automatic measurement is possible.

The present invention is not intended to be in any way limited to the embodiments described herein, which, without departing from its scope, permit many modifications to be made as regards the form, composition, arrangement and number of parts used for the realization of the invention, among other aspects.

Claims

1. A method of measuring the yarn density of a woven fabric or the stitch density of a knitted fabric by recording a video image of the woven or knitted fabric to be examined by means of a video camera, converting the video image by an analog-to-digital converter into digital video information, storing the digital video information in a digital image memory and converting said information by a central processing unit into the yarn density or stitch density, characterized in that the digital video information is converted by a digital band filter (14) with central circle frequency (ω_0) into a yarn or stitch density, and that the digital band filter (14) is arranged in such a manner that it operates according to the formula:

$$Y_k = A_n.X_{k-n} + A_{n-1}.X_{k-n+1}\ldots.. + A_0 X_k - B_1.Y_{k-1} - B_2 Y_{k-2}\ldots - B_n Y_k$$

wherein:

X_k represents a series of points of the digital information characteristic at interspace T before the digital filtering; Y_k represents the said series of points k of the filtered digital information characteristic via digital filtering at the same interspace T; the coefficients A and B are a function of the quality Q, the central circle frequency ω_0 and the interspace T.

2. A method as claimed in claim 1, characterized in that the central circle frequency ω_0 of the band filter (14) is adjustable as a function of the yarn or stitch density of the fabric (1) to be examined.

3. A method as claimed in claim 1, characterized in that the information converted by the central processing unit (7) is supplied to a suitable display unit.

4. A method as claimed in any one of claims 1-3, characterized in that before conversion of the digital video information, this information is enhanced.

5. A method as claimed in claim 4, characterized in that the enhancement of the digital video information includes at least one of the following

steps: contrast expansion, elimination of redundant information from the digital video information and accentuation of relevant information in the digital video information.

6. A method as claimed in claim 1, characterized in that the yarn or stitch frequency graph (12) is computed by isolating one line from the digital video information.

7.A method as claimed in claim 1, characterized in that the information corresponding with the yarn or stitch frequency graph (12) is determined by the computation of a row or column histogram from the digital image information.

8. A method as claimed in any of the preceding claims 1-7, characterized in that the yarn or stitch density is computed by the digital filter (14), by computing the average of the filtered information corresponding with the yarn or stitch frequency graph (17), subtracting said average from said filtered information, counting the number of whole periods N in the filtered information, counting the number of measuring points N_p in said N periods, and resolving the equation:

density = $N/(N_p \times s)$, in which s is a scale factor.

9. An apparatus for measuring the yarn density of a woven fabric or the stitch density of a knitted fabric, characterized in that it comprises:

- a video camera (4) for recording an analog video image of the woven or knitted fabric (1) to be examined,
- an analog-to-digital converter (5) for converting the analog video image into digital video information,
- an image memory (6) for storing the digital video information, and
- a processing unit (7) for converting the digital video information into the yarn density or stitch density by means of a digital filter (14) with central circle frequency ω_0.

10. An apparatus as claimed in claim 12, characterized in that it comprises a suitable display unit (8).

11. An apparatus as claimed in any one of claims 9 and 10, characterized in that it comprises means for calculating a yarn or stitch frequency graph (12).

12. An apparatus as claimed in claim 11, characterized in that it comprises a computer unit (15) for determining the yarn or stitch density computed by the digital filter (14), corresponding with the yarn or stitch frequency graph (17).

13. An apparatus as claimed in claim 12, characterized in that the digital filter (14) is a digital band filter whose central circle frequency ω_0 can be adjusted in function of the yarn density or stitch density of the woven or knitted fabric to be examined.

14. An apparatus as claimed in claim 13, characterized in that the digital filter (14) is a digital low-pass filter.

15. An apparatus as claimed in claim 14, characterized in that the digital filter (14) is a digital high-pass filter.

16. An apparatus as claimed in any one of claims 9-15, characterized in that it comprises an image enhancing unit (11) for enhancing the digital video information, which comprises at least one of the following devices: a device for contrast expansion, a device for elimination of redundant information from the digital video information and a device for accentuation of relevant information in the digital video information.

17. An apparatus as claimed in any one of claims 11-15, characterized in that it comprises means (13) for isolating one line from the digital video information.

18. An apparatus as claimed in any one of claims 11-15, characterized in that it comprises means (13) for computing a row or column histogram from the digital image information.

19. An apparatus as claimed in any one of claims 9-18, characterized in that it comprises at least one source of light.

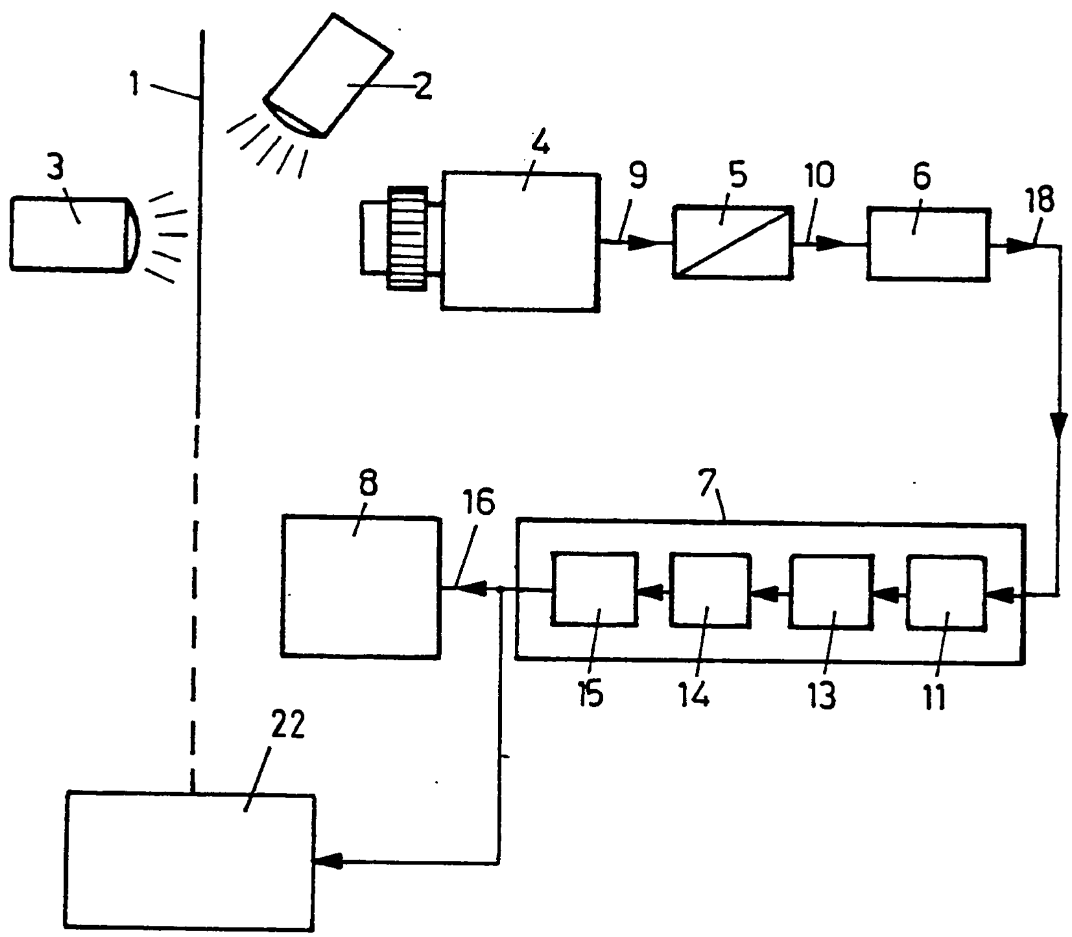


FIG.1

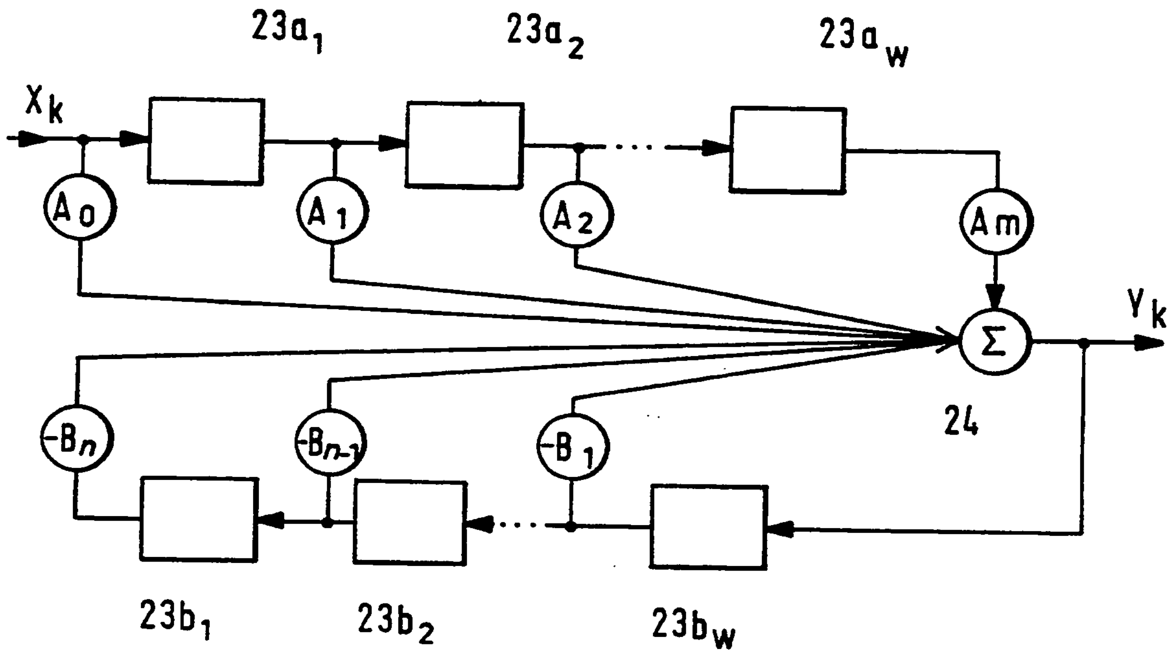


FIG. 2

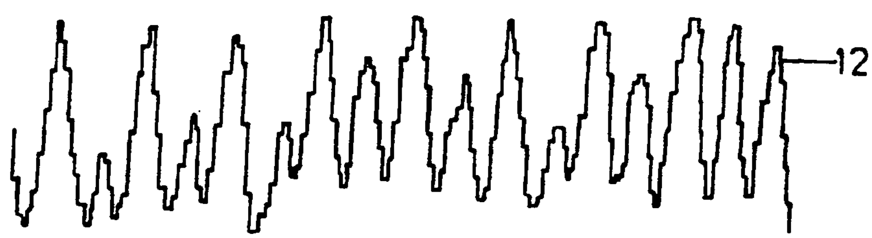


FIG. 3

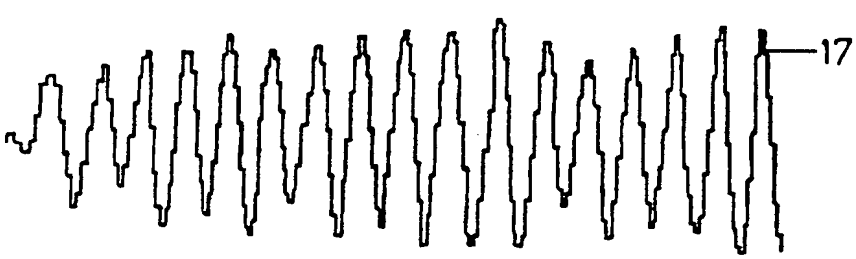


FIG. 4

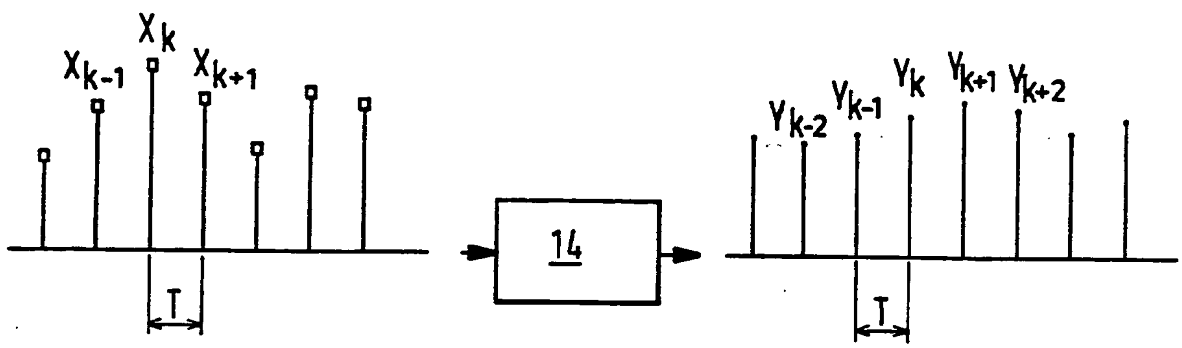


FIG.5

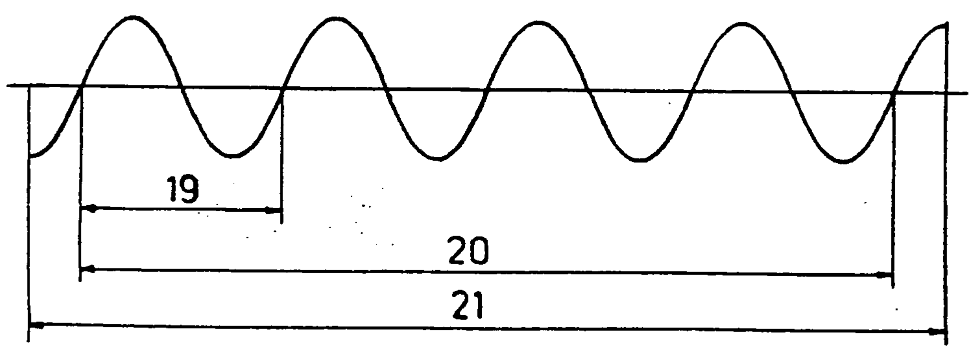


FIG.6

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 277 694 A3

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88200167.0

(51) Int. Cl.[5]: G01N 33/36

(22) Date of filing: 02.02.88

(30) Priority: 05.02.87 BE 8700088

(43) Date of publication of application: 10.08.88 Bulletin 88/32

(84) Designated Contracting States: BE CH DE ES FR GB IT LI

(88) Date of deferred publication of the search report: 17.10.90 Bulletin 90/42

(71) Applicant: Wetenschappelijk en Technisch Centrum van de Belgische Textielnijverheid, afgekort tot Centexbel
Montoyerstraat 24
B-1040 Brussels(BE)

(72) Inventor: Bossuyt, Filip Oktaaf Pieter
Burgemeester Coussensstraat 9
B-8000 Kortrijk(BE)

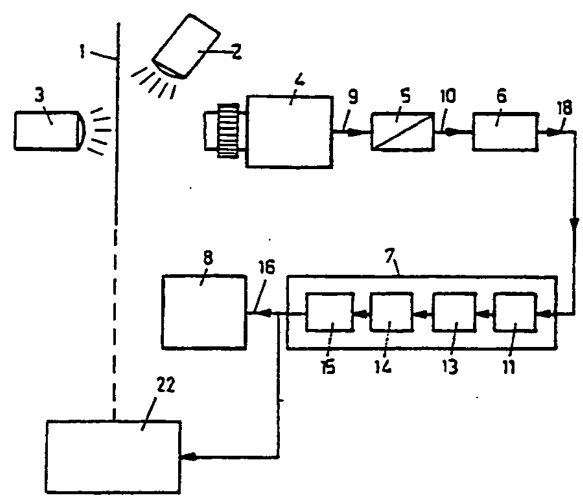
(74) Representative: Debrabandere, René et al
BUREAU DE RYCKER Vereenigde Octrooibureaux Belgie N.V. Arenbergstraat 13
B-2000 Antwerpen(BE)

(54) A method of measuring the yarn density of a woven fabric or the stitch density of a knit fabric for readjusting the production machine in question.

(57) A method of measuring the yarn density of a woven fabric or the stitch density of a knitted fabric by recording a video image of the woven or knitted fabric to be examined by means of a video camera, converting the video image by an analog-to-digital converter into digital video information, storing the digital video information in a digital image memory and converting said information by a central processing unit into the yarn density or stitch density. The digital video information is converted by a digital band filter (14) with central circle frequency (ω_0) into a yarn or stitch density, and that the digital band filter (14) is arranged in such a manner that it operates according to the formula:

$$Y_k = A_n.X_{k-n} + A_{n-1}.X_{k-n+1} .... + A_0X_k - B_1.Y_{k-1} - B_2Y_{k-2}... - B_{-n}Y_k$$

wherein:
Y_k represents a series of points of the digital information characteristic at interspace T before the digital filtering; Y_k represents the said series of points k of the filtered digital information characteristic via digital filtering at the same interspace T; the coefficients A and B are a function of the quality Q, the central circle frequency ω_0 and the interspace T.



FIG·1

EP 0 277 694 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 20 0167

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	L.R. RABINER et al.: "Theory and application of digital processing", pages 40-45, Prentice-Hall, Englewood Cliffs, New Jersey, US * Page 40, paragraph 2.19 - page 43 * ---	1	G 01 N 33/36
Y	EP-A-0 160 895 (R. MASSEN) * Front page * ---	1	
A	US-A-2 882 785 (R.L. BIESELE) * Column 3, lines 37-43; figure 4 * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 01 N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-08-1990	DUCHATELLIER M.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document